

Eco Char	Vital Sign Category	Monitoring Objectives	VS Id#	Vital Sign	Monitoring Question(s)	Management Goal	Monitoring Method	Metrics	Vital Sign Rank (0-5)	Comments / Notes
Physical / Chemical Conditions	Soil, Water, & Nutrient Dynamics	Monitor soil erosion	P12	Soil Erosion	What are causes and locations of soil erosion?	Understand patterns of soil erosion, minimize effects on resources	erosion pins, sediment collectors, mapping	Rate of change?	2.9	
			P13	Soil Quality - Biological	Are soil communities changing?	Identify trends in soil quality and evaluate potential for climate change analysis	Soil sampling and analysis	bacteria, fungal/microrhizal, worms/nematodes/arthropods	1.7	
		Monitor soil quality trends (physical, toxics/contaminants, other biologic and nutrients)	P14	Soil Quality- Chemical	Are soil buffering and filtering qualities changing?	Identify trends in soil quality and evaluate potential for climate change analysis	Soil sampling and analysis	appropriate WQ measures, cations, pH, soil composition, Total Nitrogen & Total Carbon	1.9	
			P15	Soil Quality- Physical	Are physical soil properties changing?	Identify trends in soil quality and evaluate potential for climate change analysis	Soil sampling and analysis	DOC, grain size, moisture content, parent material, percent organic matter, permeability, POC	2.3	
		Monitor condition and extent of soil crusts	P16	Soil Crust Change (Arid-Semiarid habitats)	What are pressures/impacts on soil crusts, and how are they distributed in space and time?	Document change and analyze for trend	soil and geologic mapping, remote sensing, periodic change analysis	distribution of soil crusts, pH, rainfall, substrate composition, volcanic aerosol composition, wind spd/dir	0.9	
		Monitor trends in surface water flow regimes	P17	Flowing surface water hydrology	What are usual rates & range of flow? What is timing & magnitude of floods or droughts? Is erosion occurring, or are flow channels changing?	Understand patterns in surface water flow regimes & stream dynamics	gages, sampling at permanent sites	erosion, discharge / recharge, diversion patterns, flood timing / magnitude, withdrawal & consumption rates, stream cross-section, stream discharge, stream gradient	2.7	
		Monitor wetland (incl. anchialine ponds) water flow exchange dynamics, size, and distribution	P18	Wetlands (incl. anchialine pools) hydrology	What are freshwater/saltwater recharge rates? What is habitat extent? What are temporal trends in recharge rates and habitat extent?	Understand patterns in water flow and recharge in surface features associated w/groundwater	measure salinity, residence time, mapping	erosion, flood timing/magnitude, flow, parent material/geomorphology, plant cover/ species present, pool size, depth & salinity, rainfall, sediment loads, stream cross-section, stream discharge, stream gradient	3.2	
		Monitor ground water flow rates and direction of movement (recharge)	P19	Groundwater dynamics	What are rates of subsurface flow? What is level of freshwater/saltwater mixing? What are flow patterns?	Understand patterns & rates of flow in subsurface groundwater resources	well, seep, & spring discharge measurements	discharge/recharge, injections (sewage), permeability, tide fluctuations, withdrawal & consumption rates	2.4	
Physical / Chemical Conditions	Hazards	Monitor surface volcanic activity (lava flows, eruption events & ground deformation)	P34	Volcanic Unrest - Ground Deformation	What role does volcanic activity and deformation play in maintaining public safety, park facilities, and how do they affect natural processes?	Monitor volcanic activity and ground deformation patterns	Dry and wet tilt meters, dilatometers, GPS	GPS, subsurface temp, tilt meters	1.4	
			P35	Volcanic Unrest - Lava Flows	What role do lava flows play in maintaining public safety, park facilities, and how do they affect natural processes?	Monitor activity; model risks/hazards	Remote sensing, visual observation, tilt meters and dilatometers, GPS ground deformation	tube mapping, flow direction/magnitude, GPS	1.2	
		Monitor volcanic & non-volcanic seismicity	P36	Seismicity of Non-Volcanic Origin	Can we identify trends and predict hazards?	Monitor activity; model risks/hazards	Seismometers (local and global)	tilt meters, seismometers, dilatometers (pressure gauges), EDM (Electronic Distance Measuring)	1.9	
			P37	Seismicity of Volcanic Origin	Can we identify trends and predict hazards?	Monitor activity; model risks/hazards	Seismometers (local and global)	tilt meters, seismometers, dilatometers (pressure gauges), EDM (Electronic Distance Measuring)	1.8	
		Monitor extent, location, and causes of mass wasting events (e.g. landslides)	P38	Mass Geologic Wasting	Can we predict slope failure hazards to protect habitats and human safety? Can we monitor or identify causes? What are temporal trends?	Document and measure events. Identify threats to habitats, water resources, and humans.	Rainfall and other climactic analyses (precursors and catalysts), stream gauges, remote sensing	soil saturation, soil/ground creep, substrate composition/permeability, substrate distribution	1.6	
	Geology	Monitor shoreline dynamics	P39	Coastal Shoreline Change (erosion & accretion)	Where are shorelines advancing, retreating, or stable?	Document change and analyze for trends	tide gauge, GPS, remote sensing, field investigation, periodic change analysis	human development/infrastructure, substrate composition, shoreline aspect/position/slope, sea level, nearshore physical oceanography	3.2	
		Track dune locations and topography	P40	Dune Change (erosion & accretion)	Are drought & desertification influencing topsoil transport and seed/nutrient transport patterns?	Monitor dune formation/reactivation and wind erosion patterns	remote sensing, field investigation, periodic change analysis	grain size & parent material, rainfall, soil crust development, substrate composition, substrate distribution, veg stabilization, wind spd/dir	0.9	
		Identify and monitor the extent of permafrost	P41	Permafrost on Big Island summits	Is extent of permafrost declining? Influence on ground subsidence, slope failure, etc?	Monitor changes in permafrost	Remote Sensing (ground penetrating radar), satellite thermal analysis, drilling	temperature, volcanic activity (heating), permafrost thickness, rainfall	0.0	
			P42	Cave Environmental conditions	Are cave systems impacted and changing as a result of above ground changes or human activity & cultural practices? Are environmental conditions in caves changing (temp, humidity, light, etc.)?	Ensure integrity of cave systems by maintaining environmental habitats as well as cultural uses and resources	Station/plot data	litterfall, Species distribution & abundance, human use levels, temperature, humidity, ground compaction, etc.	2.0	
		Monitor karst and non-karst cave and lava tube habitat characteristics, topography, and extent	P43	Cave Geology: non-karst	What are patterns of mineral accretion? Where & when are collapse/skylight formation or enlargement occurring?	Document changes in resource, ensure public safety	geologic mapping, periodic measurement of physical parameters and feature types	dimensions, feature size, extent	2.2	
			P44	Cave Geology: karst	Are changes in karst systems leading to potential bedrock collapse, well yield disparities, poor groundwater quality, soil instability?	Determine trends in karst systems -- growth of caves, declines in groundwater quality, etc.	Geologic mapping, remote sensing, surface water chemistry, groundwater discharge patterns	baseline mapping, groundwater flow/quality	0.9	

Intro, Monitoring goals & objectives, Conceptual Models, and Vital Signs

Also use main handout of review materials (http://www.nature.nps.gov/im/units/pacn/monitoring/plan/vs04/review_materials.htm)

Ecological Characteristic	Vital Sign Category		Monitoring Objectives
Human activities & cultural practices	Soundscapes		Monitor sound sources, frequencies, occurrence, and levels
	Viewscapes / Lightscapes		Monitor landscape / seascape appearance Monitor light levels and characteristics of light/dark cycles
	Land Use		Monitor points of entry for invasive species Monitor water use adjacent to or upstream from park boundaries Monitor land use adjacent to, or upstream of, park boundaries
	Park Use & Activities		Monitor debris-trash occurrence in coastal, riparian, wetland, and lacustrine habitats; in or near high use areas Monitor patterns of park visitation, use & damage (terrestrial & marine) Monitor incidence & occurrence of bioprospecting
	Management Zones		Monitor levels of take & harvest of harvested species (marine, freshwater, and terrestrial) or resources (coral, sand) Monitor patterns and effects of use and management Monitor effects of management practices on wilderness character
			Monitor visibility Track rates of atmospheric deposition Track atmospheric concentrations of particulates and gases, levels of radiation--emphasizing those with known human health or environmental impacts Monitor core weather/climate conditions within each park (on each island) Monitor frequency and intensity (severity) of extreme events (hurricanes, waves, winds, rain, etc.) Identify and monitor spatial patterns of climate, such as trade-wind inversion elevation, lifting condensation level, lapse rates, etc.
Physical / Chemical Environment	Climate & Air Quality		Monitor physical ocean dynamics--ocean currents, sea level, tides/swell Monitor cycles of nutrients and elements within soils and water--including carbonate (oceanic), nitrogen, and phosphorous Monitor soil erosion Monitor soil quality trends (physical, toxics/contaminants, other biologic and nutrients) Monitor condition and extent of soil crusts Monitor trends in surface water flow regimes Monitor wetland (incl. anchialine ponds) water flow exchange dynamics, size, and distribution Monitor ground water flow rates and direction of movement (recharge)
	Soil, Water, & Nutrient Dynamics		Monitor water quality core parameters Monitor supplemental water quality parameters Monitor microbiological water quality parameters Monitor toxic and contaminant levels in water Monitor biological invertebrate communities
	Water Quality		Monitor surface volcanic activity (lava flows, eruption events & ground deformation) Monitor volcanic & non-volcanic seismicity Monitor extent, location, and causes of mass wasting events (e.g. landslides)
	Geology	Hazards	Monitor shoreline dynamics Track dune locations and topography Identify and monitor the extent of permafrost Monitor karst and non-karst cave and lava tube habitat characteristics, topography, and extent
		Landforms	
Biotic Integrity	Terrestrial Ecosystems	Vegetation	Monitor patterns of distribution & extent of community types Monitor fire regimes and effect on vegetation Track insect and disease presence during forest dieback
			Monitor community dynamics, structure, function, and composition Monitor effects of management on native communities
			Monitor effects of biocontrol on native and invasive species Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
			Monitor disease incidence and impacts, especially on native species Monitor extent and response to treatment of established invasive species Monitor occurrence of non-established (incipient) invasive species
		Consumers	Monitor community dynamics, structure, function, and composition Monitor effects of management on native communities
			Monitor effects of biocontrol on native and invasive species Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
			Monitor disease incidence and impacts, especially on native species Monitor extent and response to treatment of established invasive species Monitor occurrence of non-established (incipient) invasive species
			Cave Systems Community Monitor changes in cave communities
		Freshwater Ecosystems	Producers Monitor community composition, structure, and productivity
			Community Monitor community dynamics, structure, function, and composition
			Monitor disease incidence and impacts, especially on native species
			Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
			Monitor extent and response to treatment of established invasive species Monitor occurrence of non-established (incipient) invasive species
	Marine Ecosystems	Benthic	Landscape Monitor patterns of distribution & extent of community types
			Community Monitor community dynamics, structure, function, and composition
			Population Track community and population trends in harvested fisheries / collected species Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
			Monitor disease incidence and impacts, especially on native species Monitor extent and response to treatment of established invasive species Monitor occurrence of non-established (incipient) invasive species
		Water column (motile)	Community Monitor community dynamics, structure, function, and composition
			Track community and population trends in harvested fisheries species Monitor disease incidence and impacts, especially on native species Monitor extent and response to treatment of established invasive species
			Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
			Monitor occurrence of non-established (incipient) invasive species
		Intertidal	Community Monitor community dynamics, structure, function, and composition
			Track community and population trends in harvested fisheries collected species Monitor population size and distribution of native, endemic, or focal species, including response to restoration efforts. Where appropriate, measure demographics (size/age structure, reproduction, recruitment, etc.) of selected indicator species
			Monitor extent and response to treatment of established invasive species Monitor occurrence of non-established (incipient) invasive species